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THE EFFECT OF HYBRIDIZATION OF HOST-PLANT STRAINS ON GROWTH RATE AND MORTALITY OF PIERIS RAPAE[1]

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IT HAS BEEN PREVIOUSLY SHOWN (Hovanitz and Chang, 1962) that larvae of strains of *Pieris rapae* differ in their mortality rate, growth rate and final size dependent upon the plant which is supplied them for food. Slightly greater viability, greater rate of growth and increased size are characteristic results of feeding the larvae on kale *(Brassica oleracea* var. *acephala)* as compared with mustard *(Brassica nigra),* even though both plants are utilized by the species in the wild.

It is the purpose of this paper to report on the results of an experiment designed to compare these physiological factors in strains bred for several generations on each plant and then hybridized.

THE STRAINS

The strains of *Pieris rapae* used in these experiments were derived originally from two sources, both in the Los Angeles Basin of southern California. The first, here designated the kale strain, originated with wild females obtained in a cabbage field *(Brassica oleracea* var. *capitata)* in a truck crop growing area in western Orange County, near Huntington Beach. The other, here designated as the mustard strain, originated in the fields of the Los Angeles State and County Arboretum, where in the spring time *Pieris rapae* may be found in conjunction with black mustard *(Brassica nigra).* These have probably had no recent contact with cabbage since there are none grown commercially within nine miles of the area. Before testing in the experiments here described, the kale strain had passed through more than ten generations in the laboratory on kale and the mustard strain had passed through more than six generations in the laboratory on mustard.

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THE COMPARATIVE TESTS

Six comparative tests were run contemporaneously, consisting of twenty larvae each. These larvae were fed in petri dishes by daily changes of food, keeping each larvae well isolated from the others. It was especially important while they were small that the larvae were placed directly on top of the leaf of the plant. Of the six tests, two were of the parent strains; one of these was derived from kale and fed on kale during the experiment, while the other was derived from mustard and fed on mustard during the experiment. Four further sets were F_1 larvae from these two parent strains derived as follows:

One set consisted of F_1 larvae obtained by crossing a kale-strain female with a mustard-strain male and then by feeding the ensuing larvae on the food-plant of the mother (kale).

A second set consisted of larvae obtained by crossing a mustard-strain female with a kale-strain male and then feeding the ensuing F_1 larvae on the food plant of the mother (mustard).

A third set consisted of larvae obtained as in the manner of the first F_1 set above, but fed on the food plant of the father (mustard).

A fourth set consisted of larvae obtained in the manner of the second F_1 set above, but fed on the food plant of the father (kale).

MORTALITY

The mortality figures for the larvae were low in all the strains (table 1). The kale-strain parents had a mortality of ten percent, which compared well with the data previously obtained (Hovanitz and Chang, 1962). The mustard-strain parents had a mortality of thirty percent which also compared well with the previously recorded data.

The reciprocal F_1's behaved differently. When the kale-strain contributed the female parent and the mustard-strain contributed the male parent, the mortality of the F_1 larvae was twenty percent whether kale or mustard was used as food. On the other hand, when the mustard-strain contributed the female parent and the kale-strain contributed the male parent, the larvae had only a ten percent mortality when used on kale and zero percent mortality when bred on mustard. It is doubtful that these slight differences are significant for the N value of 20, though they may represent a real difference. It is possible that the hybrids show a greater viability as a result of their heterozygosity. Both parental strains have been considerably inbred during their maintenance in the laboratory. No reason can be given at this moment for the greater viability of the mustard female F_1's (10 and 0 percent) as compared with the reciprocal kale female F_1's (20 percent each).

LENGTH OF LARVAL PERIOD

The minimum length of life for the larvae from the egg to the adult for both of the parental strains was twenty-five days under the conditions of the experiment (table 1). *All four of the hybrid F_1 strains had a shorter larval length of life indicating a greater activity than the inbred parental strains.* The rate was speeded up to twenty-two days for the F_1 strains in which the female parent was derived from kale stock.

	Type	Strain No.	No.	No. and %	Minimum days from egg to pupae
Parents	Kale-bred	5	20	2 10%	25
	Mustard-bred	6	20	6 30%	25
F_1 Kale ♀ x Mustard ♂	Kale-bred	2	20	4 20%	22
	Mustard-bred	1	20	4 20%	22
F_1 Mustard ♀ x Kale ♂	Kale-bred	4	20	2 10%	21
	Mustard-bred	3	20	0 0	23

Table 1. The comparative mortality and length of larval growth period of various strains of Pieris rapae.

For the F_1 stock in which the female parent was derived from mustard, the larvae bred on kale were speeded up to twenty-one days and those bred on mustard to twenty-three days. These data definitely indicate a significantly greater activity of the hybrid strains than the parental. However, there is no indication of any maternal effect on the inheritance of food-plant preference since the reciprocal crosses indicated the same general effects on mortality and growth rate whichever strain contributed the female parent.

GROWTH RATE AND MAXIMUM SIZE

The growth rate of the six sets of larvae was compared by measuring ten of the living larvae daily from the time of hatching from the egg to the time of pupation. The average of these ten measurements was plotted daily and curves drawn to illustrate their size increases (fig. 1). Differentiation between the curves occurred within the first few days but the first five days have been omitted in fig. 1, owing to the small size of the larvae. *On the fifth day, both parental strains had the smallest larvae while the two F_1 strains, in which the kale-strain female parent was used, had the largest larvae. The other two F_1 strains, in which the mustard-strain female parent was used, were intermediate.* During the entire growth period, nearly the same relationships held, with the exception of the kale-bred F_1 with a mustard-strain female

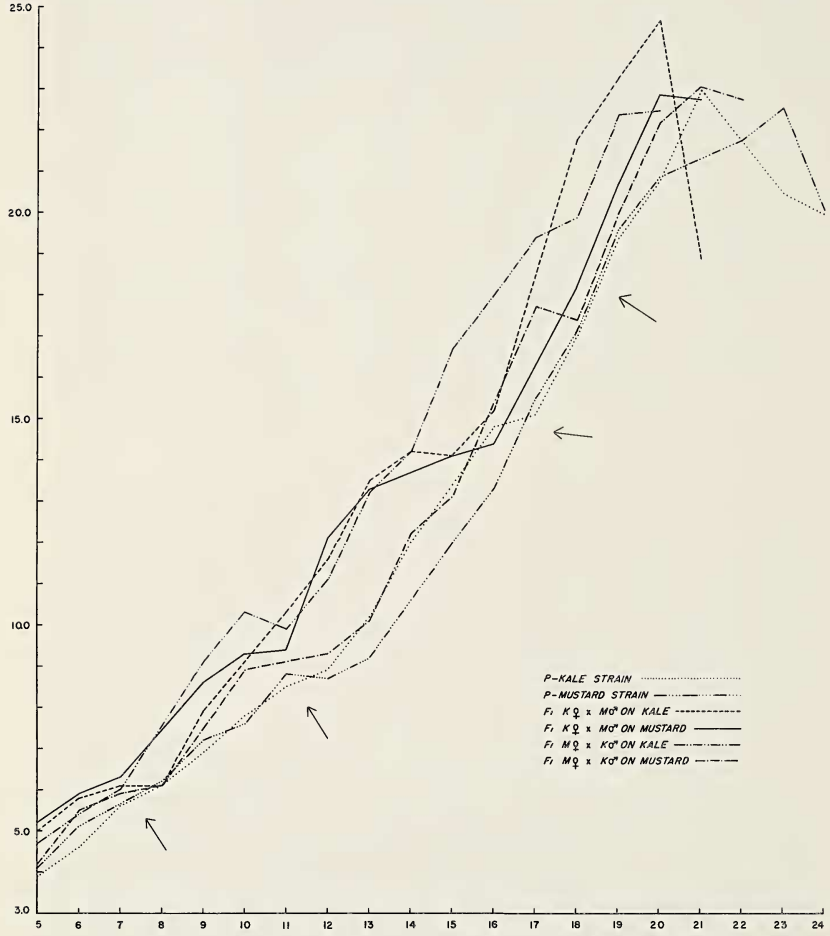

Fig. 1. Growth rates of larvae of six strains of *Pieris rapae* on kale and mustard. Vertical scale, length in mm.; horizontal scale, days after hatching from egg to pupation.

parent which for a time was faster than all the others. Of the two parental groups, the mustard-bred larvae were larger than the kale-bred at five days, but the kale-bred reached a maximum ahead of and larger than the mustard-bred. *Of the three groups on kale as compared with the three on mustard, the kale-bred group in each case reached a maximum size larger than or earlier than the comparable group on mustard. Of the parental as compared with the F_1 groups, the larvae of both F_1 hybrid groups consistently exceeded the larvae of the parental groups from the beginning to the end.*

The largest maximum size was attained by the F_1 group in which the female parent was derived from a kale-strain and in which the larvae were kale-bred. On the other hand, *the second largest maximum size was attained by the larvae of the F_1 group bred on mustard but which had a mustard-strain mother.*

It may be observed from the curves that at the periods of molting, sizes of the larvae are reduced. These periods are shown by the arrows (fig. 1). Because these reduction periods are delayed for the slower larvae, the older the larvae, the more difficult it is to compare the six groups on any one day.

SUMMARY AND CONCLUSIONS

1. Crosses were made between strains bred for many generations on kale and mustard.

2. The effect of hybridization between these host-selection strains has been to speed up development, to bring about increased sizes to the larvae, and to reduce mortality. These effects are probably due to the genetic effects of "hybrid vigor", in which the deleterious effects of inbreeding within the host-selected strains have been reduced by outcrossing.

3. These effects are greatest for the kale-strain than for the mustard-strain. This would tend to confirm our previous findings that kale is preferred as a food over mustard, even when mustard is utilized as the food for many generations.

4. The increased viability, increased growth rate and increased size of the larvae are greatest when the hybrid larvae are grown on the plant corresponding to the strain of the mother, rather than the father. For example, the F_1 hybrids where the mother was of the kale-strain grow larger and pupate sooner on kale than on mustard. Likewise, the F_1 hybrids where the mother was of the mustard-strain grow larger but not faster on mustard than on kale.

LITERATURE CITED

HOVANITZ, W. and VINCENT C. S. CHANG. 1962. The effect of various food plants on survival and growth rates of *Pieris* *J. Res. Lepid.*, 1(1): 21-42.